The challenges of Interstellar Travel

A layman's discussion

By Hector Vladimir

Challenges With Interstellar Travel

By Hector Vladimir

November 2024 – January 2026

Introduction.

An interstellar project would be humanity's largest undertaking by far. Topping the efforts made by entire empires like the Ancient Egyptian empire's mountain-like "Pyramids", or the Ancient Chinese's efforts in building its continent-spanning "Great Wall". Not only that, but it would also top any modern mega project undertaking, such as the Hoover Dam and the Panama Canal. An interstellar program would dwarf the United States' Apollo program that took a few men to the moon; and the multi-decade Russian Trans-Siberian Railway construction. In fact, I believe an interstellar program would compare to many of these, and other comparable mentioned undertakings combined. In fact, I believe it would take no less than the full cooperation, resources, and technical capacity of the entire industrialized world.

To have a shot at visiting even the nearest star system, two methods may be used. Method one is to get there extremely fast; limiting as much as physically possible the time required to get there. This would spare some complexity, costs and resources required for the mission. This may also minimize the ill effects that such an odyssey would lay on its human crew. This method, however, requires leaps and bounds in our technologies and understanding of the universe.

Method 2 accepts our current (or reasonably attainable) technological state, and settles with relatively slow travel times, current ship systems technology, and long "long" trip durations. However this exponentially complicates the mission, and requires us to recreate Earth conditions on the ship to ensure a gradual generations long completion of the mission.

Unfortunately, we currently lack both the propulsion means to shorten trip times, and the ultra-advanced technologies required for the immense complexity and scale of such undertaking. For example, to duplicate Earth conditions on a ship bound for an Interstellar voyage; the ship would have to be more of a habitat than a spacecraft. But, one that propels itself to unimaginably high speeds, likely on the kilometer scale, and requiring earth orbit-based assembly and launch.

We, as a world, I believe lack the political will, economic prowess, and global cooperation commitment required to organize the interstellar program necessary. And, realistically, we lack the ability to generate the energy required to undertake a viable interstellar ship construction and feed its

propulsion system for mission completion. Some calculate that this energy requirement is in the order of gigawatts. [citation pending cp].

Additionally, NASA's 5 hazards of space flight would also apply to any Interstellar voyage. These are unsolved challenges that prevent us from settling even nearby celestial bodies such as the moon or mars. These hazards are the human exposure to space radiation; the ill effects of altered gravity fields; the technical challenges introduced by the distance from Earth; and the challenges with human isolation and hostile-closed environments.

It is humbling to recognize that our most extreme efforts in space have only strenuously propelled crews only as far as the moon's surface, and to construct and crew a few space stations a few hundred kilometers into space. Recognizing this, at this time, it seems nearly inconceivable that a human crew would be able to reach another star system. Especially when considering our currently “retarded” state of space technology, energy production, economic distribution, and effectiveness in government.

Also, an Interstellar trip to the nearest star system will likely be a one-way trip, for the crew and their descendants, since a planned return to earth would be several thousand years more into the future, and risking returning to a utterly unrecognizable and hostile world. Those taking part of the voyage, if it ever materializes, will have volunteered for permanent excommunication and commit to becoming another species of humanoid altogether.

Lastly, for now, I believe we may only keep dreaming, and trying to bring about the conditions necessary to favor the rapid developments needed to begin to inch into a global “space faring civilization”. But, perhaps, our slow but commendable ability to strive and discover; may be what “slowly-but-surely” takes us to the stars. But, I believe there is another thing, perhaps surprising to some, that may give us a better shot at the stars. I’ll tell you about that at the “grand finale” of this article.

Section 1.

Physical challenges.

Space is vast and full of complex and little-understood phenomena. Here I'll discuss what I believe to be important physical challenges to consider, when thinking of interstellar travel. There is the [1] unfathomable distance between star systems; [2] the all around damaging ionizing cosmic radiation; [3] the debilitating lack of gravity, on the vast space between celestial bodies; [4] the inhospitable temperatures of most of the expanse of space; [5] the fluid boiling vacuum of space; [6] the ever-present danger of explosive collisions with "heavenly bodies"; and of course, [7] all of the "unknown" that may help us, as well as harm us.

As you may know, these physical challenges are part of the almost immovable nature of the universe as we understand it. And these will remain unchanged, unless an unimaginably-different nature of the universe is discovered and understood. And, I believe these physical barriers currently remain uncleared, and prevent the achievement of interstellar flight. For instance, our laws of physics prevent high- and even mid-percentages of the speed of light; from being achieved by any spacecraft. Partly due to an exponential increase in the mass of the spacecraft, as higher percentages of relativistic speeds are reached. Thus requiring exponentially higher thrust; a current impossibility. Even if relativistic speeds are somehow achieved, crews may experience harmful effects with acceleration. For instance, if we can somehow achieve 50% the speed of light, it will have to be broken down into the acceleration from 0 to 24.5%, then deceleration from 24.5% to 0%. And human biology may not deal well with the effects of these massive changes in speed; not to say anything about the complications in mission design that these would present. So, without further ado; here are these few physical phenomena, discussed briefly, which I believe stand in our way to interstellar travel.

[1]. Distance.

The unimaginable vast space between earth and Alpha-centauri will present a myriad of problems to the crew and the mission design in general. Just as a side note, here, when I speak of mission design, I'm referring to the overall mission characteristics and requirements. Such as fuel, energy and supply requirements. Among these problems is the unimaginably vast distance crews will have to travel away from earth; which itself brings the incredibly long duration of the interstellar mission, and the extreme isolation that space crews will experience. These, long duration and isolation, bring other sets of challenges like boredom, communications delays with earth, supply problems, crew

dissatisfaction, etc. Must I say here that Alpha Centauri is the nearest star system to our own; yet at a staggering 4.37 light-speed-traveled-years away. That is about 276,000 astronomical units or A.U., where 1 A.U. is the average distance from the earth to the sun, about 150 million kilometers.

For more familiar measures, we may scale 1 A.U. to 1 meter, then the distance between earth and Alpha Centauri would be 2,760 kilometers away. Still in the 1 meter equals 1 AU scale, the earth to alpha centauri distance; is about the distance from New York City to Los Angeles.

The average distance between stars in our galaxy, the milky way, is about 5 light years. And the fastest crewed rocket we have ever sent to space was the Saturn 5, which achieved an astonishing speed of about 25,000 km per hour. However, even if we can somehow sustain that speed way past the low earth orbit; it would still take that spacecraft about 188,000 years to reach the Alpha-centauri star system. [*].

The fastest uncrewed space probe we have ever sent to space is the Parker solar probe. It achieved a stupendously fast speed of 692,000 km per hour. But, even at this mind boggling speed, it would take 72000 years to reach Alpha-centauri.

To reach Alpha-centauri in a reasonable time, say 22 years, spacecraft would need to reach, and maintain, about 20% of the speed of light or 0.2c. However, traveling at 0.2c poses unknown and unsettling consequences for the spacecraft and its precious human crew. Not to mention the real dangers posed by the concentrated space radiation and the high risk of explosive collisions with interstellar particles. At this speed (0.2c), even individual atoms, and tiny dust particles, can cause substantial damage to a spacecraft. At the bare minimum, the energy deposited by these micro-collisions can lead to local craft heating and some structural damage. At worst, it may cause spacecraft evaporation! Still, at 0.2c, it would take any spacecraft 6820 years to reach the Alpha-centauri system!

Yet, reaching 0.2c is no small feat. That’s 1,079,251,200 km per hour, or about 1560 times faster than the speed of our fastest space probe yet. And, counting on “soon-to-come” breakthroughs, with spacecraft propulsion, just won’t do if we are serious about interstellar treks. We must admit that, considering the odds, reaching relativistic speed is just outside of our reach, and not something we should “count on” for interstellar travel.

[2]. Ionizing radiation.

Space radiation is among the most hazardous dangers for astronauts on long duration space flights. Ionizing radiation are high energy particles from nearly all of elements, in their atomic

composition. These are flying all around in space; speeding at nearly the speed of light. They can damage or destroy the atomic composition of meterials they come in contact, icluding human cells and DNA. Ionizing radiation comes from deep space explosive events, such as supernovae, star atmospheres, and other sources. Recall the last episode, where it was mentioned that a spacecraft traveling through space at 0.2c; would expose its human crew to radiation. Well this is ionizing radiation, and it was determined the radiation levels are close to those encountered in a nuclear reactor. Ouch! And, it is known that radiation exposure will increase your chances of degenerative diseases and cancer; many fold! Interstellar space is a literal radiation furnace. For instance, 1 sievert (Sv) equals the radiation dose of about 500 medical chest x-rays. And, without accounting for the effects of speed; a 22-year journey in deep space, the cumulative dose could exceed 10 Sv! Needless to say that this exposure is well above the threshold for acute radiation sickness, and poses a severe risk of long-term health effects, including cancer and cardiovascular diseases. So, a wide array of neurological and biological health problems can be expected with the unprotected exposure to this ionizing radiation; including cancer. More disturbingly, even at low relativistic speeds, the radiation levels would be almost certainly lethal; especially when considering the vast distances and times we must traverse between stars, and our current lack of protective systems developed.

We know that lead, water, and human waste can be used to shield some of the radiation from space. But, these are partial protectants and cannot be counted-on for the long durations and exposures of interstellar travel. Especially when these have to be lifted from the surface of the earth; potentially adding many thousands of metric tons of weight to our already anemic payload capacities. And, again, force fields are still things of science fiction. We lack the energy capapcity and superconductivity necessary for even small scale magetic fields; let alone the gargantuan scales necessary on an interstellar craft. Finally, magnetic fields bring about a set of other challenges to mission design, and electrical and electromagnetic-sensitive equipment onboard.

[3]. Gravity.

Gravity is a big problem in deep space. It causes muscle atrophy, bone density loss, cardiovascular changes, body fluid redistribution, immune system impairment, vision changes, and psychological effects. Yet, we have not developed systems that can reliably and safely generate gravity on any spacecraft. Systems that spin the body locally, on a conventional spacecraft, are sickening and disorienting for the crew. And, gigantic tourus structures that spin on an axis and generate a comfortable and safe centrifugal force gravity; are still outside of our design, building, and propulsion capacity. Furthermore, if we could somehow accelerate a ship to 9.81 meters per second squared, the

acceleration of 1G; would conveniently provide the earth like gravity on surfaces perpendicular to the direction of travel. But, again, such acceleration is no small achievement. For example, at the unbelievable speed of 0.2c and a 22 year trip time to Alpha Centauri; an acceleration of 1.72 meters per second squared is what is required. Any higher acceleration is just a fantasy discussion. Additionally, in this scenario, the spacecraft would have to accelerate the first half of the journey, then decelerate on the second half. This would severely complicate mission design; such as methods used to accelerate and decelerate, and relative positions of the crew, spacecraft and its propulsion systems.

Although, as of today, low gravity is an ulsoved problem for space travel; I believe it is one that can be solved through mission and spacecraft design and using current technology. However, these require massive advances in our overall space capabilities.

[4]. Temperatures.

The average temperature of deep space is a mere 2.7 degrees kelvin (K), or -270 degrees celsius (C). These bone-chilling temperatures present obvious problems for any interstellar mission design. The insulation on such a ship will need to be significant and of high insulating materials. Luckily these have been developed, they'd just have to be scaled up to cover immense structures. And, the heat energy required, to keep a kilometer-scale interior at a balmy 16 degrees C; would be more than we can currently provide. Obviously, straying away from our sun's warming radiation, as will be necessary for an interstellar mission, will present a daunting energy challenge onboard. The sun has been our primary source of energy for all time, and the bone-shattering temperatures on planetary surfaces even within our solar system; attest to the intensity of the cold problem of interstellar space.

In contrast, any interstellar spacecraft that attempts to use a gravity assist by closely orbiting our sun (or any other star); will be exposed to tremendous levels of heat producing radiation. As you may know, the temperature at the surface of our sun is about 5500 C. And, this will have the dubious double effect of relentlessly zapping the crew with ionizing radiation; throughout the maneuver.

So, temperature extremes of interstellar space, present challenges and energy requirements that we will have to somehow surmount. I personally believe it will be a very long "long" time, before we can generate the levels of energy necessary to maintain an interstellar crew healthy and comfortable.

[5]. The vacuum of space.

The earth's atmosphere exerts pressure on the human body, about 1013 millibars or 15 lbs per square inch. In the vast space between celestial bodies; there is no atmosphere thus no air pressure. We

have evolved to live and be healthy at precisely the pressure that surrounds us on earth, anything outside of this pressure; has a negative effect on our body. A significant drop in the atmospheric pressure in direct contact with our bodies, would cause gases to expand, leading to ruptured lungs and other tissue damage. Body fluids, such as blood and saliva, would begin to vaporize, causing swelling and severe tissue damage. And, without a suitable atmosphere to mediate temperatures, the body would face extreme cold, on the shaded side of solar planets, and intense heat on the sun-exposed side. And, without the Earth's protective atmosphere and magnetic field, one would be exposed to harmful solar and cosmic radiation.

Any unprotected space dweller would experience this lack of pressure, where body fluids start boiling at normal body temperature. Followed by swelling and impaired vision due to the effects on the eyes. Decompression follows, a sickness similar to "the bends" ,experienced by some divers, when nitrogen bubbles form in the blood and tissues. Rapid decompression could cause significant cellular damage and rupturing of cell membranes. Due to hypoxia and other effects, a person would lose consciousness within about 15 seconds.

Due to these, the mission and spacecraft would have to be designed to get around the problem of no atmosphere and no pressure in space. This can simplify some mission aspects, while complicating others. No air pressure may facilitate movement of the craft and people, but would complicate having to provide a constant atmosphere and air pressure within the habitable areas of the spacecraft and spacesuits.

We currently do have systems that reliably provide suitable air and pressure for habitation. On earth, large structures like Earth 2 complex from the University of Arizona; somewhat achieved this. But, most earth structures merely transfer air and pressures from the natural environment to the interior of the structure. In space, the atmosphere needs to be manufactured and maintained. And, these would have to be much more reliable and robust than earth’s, for a long duration interstellar mission. Additionally, to provide pressure and a livable atmostphere on a kilometer scale structure in space, is no easy task. And we have little experience with this in space.

[6]. Space collisions.

Interstellar travel requires high speed, relativistic or not. To make any reasonable progress and have a better chance of reaching another star system, much higher speeds, than currently achieved by our fastest spacecraft, will be needed. However these higher speeds also increases the chances of collisions with space particles. Although few and far apart, Micrometeoroids are present in space, along

with other even larger bodies. These can cause serious spacecraft damage even at relatively low speeds. If relativistic speeds are reached, then collisions become more damaging, and particle sizes that can cause damage also decrease. This means that even dust particles can cause damage at very high spacecraft speeds.

So, for these, shielding must be part of any interstellar mission design. Physical shields or active force fields that protect the spacecraft, while in high speed travel, will be an absolute requirement on interstellar voyages. As for physical shields, as an added advantage, these may double as radiation shields for the ship and its crew. But the sizes and materials to be used are just outside of our current space manufacturing capacity. And, again, force fields are yet to be a viable option.

[7]. Unknown challenges.

Lastly, there are many unknown challenges that will be encountered in an interstellar mission, some that deal with the nature of space and time, and all of the phenomena within. With much luck, space phenomena may be discovered or understood during our research efforts en route. Such as radiation sources, dark matter, dark energy, etc. With less luck, these and others may remain mysteries for ages, or may never be understood. And, without understanding them, or even effectively detecting them, many harmful space phenomena may harm us. And, the unknown's ill effects may cause much harm to unsuspecting and unprotected interstellar crews. For example, we may unsuspectingly fly right into harmful areas of space, yet to be discovered. Or, we may veer off course, due to our ill understanding of interstellar trajectories. Long held ideas and theories may be erroneous or faulty, and current "laws" of physics may need to be revised. With luck, these "adjustments" and learning; will happen without compromising the overall mission.

Section 2.

Technical Challenges.

Mountanous technical hurdles stand before any successful interstellar trek and the present. These vary from the surmountable, such as our inability to generate gravity, and the seemingly unsurmountable; such as how to achieve a significant percentage of the speed of light. Although opinions vary widely in the scientific and popular arenas; these technical challenges are believed to be solvable, sooner or later, through applied knowledge and the formulation of effective technologies.

I believe that “leaps and bounds”, in these technical fields, will need to occur for us to engage in viable human crewed interstellar exploration. These include:

[1]. Propulsion: affecting the all-important payload capacity and speed.

[2]. Anti-radiation systems: for the protection of human crews and ship systems.

[3]. Artificial gravity systems: for the health and vitality of the crew.

[4]. Orbital ship building megastructures: to enable the building of interstellar ships and possible waystations.

[5]. Space debris shield systems: for collision protection from space debris at high speeds.

[6]. Space water and food systems: for the nourishment of generations of human crews.

[7]. Gigawatt-scale power source: for the many power hungry ship systems away from the sun.

[8]. Autonomous robotics and computing: for near-total autonomy necessary for ship navigation and protection.

[9]. Space medicine: Including genetic enhancement; microbial biology management and procreation management systems: to ensure the health and survivability of the crew.

These systems will be crucial for the planning, design, construction, training, and execution of a mission to the stars. So, when finally as a world decide to come together and embark on an interstellar mission; these are some of the technical challenges that we’ll have to overcome. So, let’s discuss in a bit more detail; shall we?

[1] Propulsion.

Currently, “snail-pace speeds” and “made-over 1970’s technology” are all we have currently been dealt; against the “dizzingly vast distances”; in the game of interstellar space. So, how do we “manage” with “what we’ve got”? Well, the odds are against us, big time! For starters, our fuel-based rockets are wholly inadequate. For example, our fastest rocket, capable of carrying a small human crew was the Saturn 5 back in the 1970s. Achieving about 25,000 km per hour, at its fastest speed of travel. However, at this speed, it may take us 188,000 years to reach the Alpha-centauri star system, the closest to our solar system. [*].

Nuclear fusion, or fission, propulsion are still non-existent. Nuclear fission reactor propulsion has the challenge of having relatively slow exhaust velocities, a no-no for interstellar flight. There is the prospect of nuclear pulse drives. Fission detonation engines. However, although these may offer higher energies and velocities; the impacts of such explosions present yet unsolved technical challenges. For example, how to dampen the recoil from the blast, how to shield the crew from radiation exposure, etc

In the other hand, nuclear fusion, if ever fully developed; offers the greatest hope for conquering many deep space propulsion problems.

Nuclear fusion energy production has been making significant strides recently! For example the WEST tokamak reactor in southern France achieved a new milestone by sustaining a super-hot plasma at 90 million degrees Fahrenheit (50 million degrees Celsius) for 6 minutes. This is a step closer to creating a sustainable fusion reaction. Also, The ITER project, also in southern France, is a major international collaboration aiming to build the world's largest tokamak. It's designed to sustain a fusion reaction for longer periods, and the project is over 50% complete, with first experiments scheduled for 2025. And, there's been a significant surge in private sector investment in fusion technology, driving scientific breakthroughs and accelerating progress. Despite these advancements, there are still significant challenges to overcome with fusion, such as finding suitable materials for reactor construction and developing mechanisms to extract and utilize the enormous energy produced. Fusion energy holds the promise of being a clean, sustainable, and nearly limitless source of power, but it's still a few decades away from commercial viability.

Ion drive propulsion is currently weak and inadequate for large scale, crewed missions. Ion drive an electrical stream produced by its engine. It is currently used on very small spacecraft that

require very little propulsion. The unimaginable speeds that interstellar travel will require will also require massive propulsion power.

To ridicule using a sail to move spacecraft in space may be unfair, but it is absolutely fair to think of this as utterly inadequate for an interstellar size spacecraft. At current times, solar sails are only practical for super-tiny “uncrewed” space probes. In contrast, a solar sail able to propel an interstellar ship; would have to be comically large. Perhaps as large as the size of the US state of New Mexico. And, once a solar sail enters interstellar space, there will be little to no light pressure to push against the sail. And, the destination star’s light pressure may slow the ship down prematurely. The obvious challenges with construction methods and materials are just too many to discuss, let alone the problems with impacting space particles.

Light beams have been proposed to move light sails. But the problems with these are vast and only lead to fantastic scenarios. Besides, the power and magnitude of a laser array able to move an interstellar craft with a light sail of thousands of kilometers squared, is just too much too even consider as currently possible. And, earth based lasers will only rotate with the earth, making space based lasers necessary, which are also currently impossible.

[1a]. Payload.

The rocket with the highest “proven” payload capacity still remains the Saturn V; developed by the United States in the 1960s and 70s. It was used during NASA's Apollo and Skylab programs. It had a payload capacity of approximately 140 metric tons (310,000 pounds) to Low Earth Orbit (LEO). A more powerful version of this rocket was being planned for NASA’s Constellation program of the mid 2000’s. Currently, the Falcon Heavy rocket, from SpaceX, is the most powerful “operational” rocket. It has an “advertised” maximum payload capacity of 63.8 metric tons (141,000 pounds), to Low Earth Orbit (LEO); in a fully expendable configuration. And around 57 metric tons (126,000 pounds) to LEO; in a partially reusable configuration. Needless to say that our previous “proven” payload has not been matched yet by any current rocket. But, the situation with our current “puny” payload capacity is even worse that this. For example, to send a crew of 5, on a 1200-day mission to Mars, it is estimated we would need to lift a “total” payload of 600,000 kg to LEO. That is 600 metric tons. Keeping in mind that our current capacity is only about 64 metric tons per launch.

Due to our limited current propulsion systems, payload capacities are...humm...Let’s call it “inadequate”. If accounting for the likely initial need to lift hundreds of metric tons of materials, to an orbital ship construction site; the payload capacity requirements “baloon-out” to hopeless figures!

These current payload limitations create a sort of “feedback loop”: where “we can’t increase our payload capacity because we are unable to build ships in orbit. And, we can’t build ships in orbit because we can’t increase our payload capacity”, and so on.

So, our first efforts, for interstellar missions, should start with goals to build ships on earth’s orbit. But, In fact I believe that nothing less than orbiting cities will enable our possibilities with interstellar travel. So, the first step to interstellar travel is actually in-orbit semi-permanent habitata (space based cities). I have written a book on this subject in the past called Colonize Space Now, the link for it is the discription section of this chat.

[1b]. Ship Size.

Considering our current state of technology, interstellar ships will likely need to house a sufficient human population for a generational interstellar mission, often called: “generational arks”. However, again; space ship size is necessarily limited to current propulsion and the payload capacities, which in turn limits our ability to build large ships on earth.

Our largest habitable structure in space, the ISS, has only a total habitable square footage of a large home; about 1293 meters squared [m^2], that is 4246 square-feet [ft^2]. And, it took over 2 decades to build the ISS to its current state. This highlights our current slow pace of development in space. Also, we currently have no operational spacecraft capable of traveling to deep space; nor one able to carry more than about a dozen astronauts per launch. Space X has the Starship craft, which may soon change this. But that is still being developed as of this writing. In fact, no space agency, or company, currently has plans to build crewed spacecraft fully-capable of solar-system deep-space (interplanetary) travel; let alone interstellar travel. So, the groundwork to begin such projects still needs to begin. That groundwork, I believe, should be based on tangible goals. And, those goals are yet to be determined. What is it that we need in space? What is it that we want in space?

[1c]. Spaceship multiplicity (number of available ships).

A mission to the stars would likely require an armada of extremely capable spacecraft. This is not only required for the trip, but also to build the orbital systems required to build an interstellar mission. Let alone to build the ship, or ships, that will actually undertake this mission. Unfortunately and currently; the number of ships we are readily able to build, for this purpose, is precisely 0. Furthermore, the megaship building infrastructure, necessary for interstellar travel, would likely be severely limited by current geopolitical and economic factors, and this is likely to remain true for the foreseeable future. So, with this we can move on to the next subjet.

[1d]. Advanced ship systems.

Advaced ship systems, as described here, are the high level, high reliability, and high precision structures, software, machines, and computers necessary for an interstellar system. Unfortunately, as we currently have nearly 0 chances to build interstellar ships, the need for these ultra advanced systems is small. So, for the foreseeable future, there will likely be a lack there of these systems, and the ships with such systems. To further define what I mean by advanced ship systesm; simply they are systems that:

1. Can propel a ship to reach a significant percentage of the speed of light;

2. Could limit travel times to human lifetimes or even one human generation to nearest star system;

3. Reliably shield from space particles at or near anywhere any percentage of the speed of light;

4. Reliably shield from space radiation during any part of the trip to the nearest star system;

5. Can generate artificial gravity;

6. Maintain human health during the long duration flight to the nearest star system;

7. Reliably grow sufficient food; and...

8. Sustain farm animals for food in space; and so on.

Anti-radiation and artificial gravity systems face significant technological and logistical hurdles, especially in the context of possible interstellar missions. And, while recent progress in materials and power generation offer hope, current capabilities severely limit their feasibility.

[2]. Anti-radiation systems.

There are two types of radiation shielding systems: passive and active. Passive shields are simply the physical structure or barrier that block or filter (lowers) the amount of radiation that gets through to the human crew and sensitive equipment. Active radiation shielding systems consist of advanced systems that generate an anti-radiation force-shield around the area to be protected; such as intense or large magnetic fields.

[2a]. Passive anti-radiation.

Passive radiation shielding may consist of a “system” of specially constructed structures working with other systems, such as automation. These may “actively” shield from most types of known radiation, and or shelters made of radiation-shielding materials. Movable structures may automatically deploy when a source of radiation is detected. The materials for passive anti-radiation are part of a growing list, but traditionally: lead metal or hydrogen-containing compounds, like water or human shit, are known to be adequate radiation filters for low duration space treks.

Water and bodily defecation, can be used as a passive radiation shield in space! This might sound a bit messy, but it's actually quite convenient. Mainly because water and bodily waste will be always available, sourced from the human crew and any other animals onboard. And, these contain compounds rich in hydrogen. Hydrogen is particularly good at blocking cosmic radiation because it effectively scatters and absorbs the high-energy particles. Additionally, using human shit, as a shield, also helps with waste management on long-duration space missions. The waste can be dehydrated to extract water, which can then be recycled for drinking. And, since spacecraft have limited room, using materials that are already on board, like human waste, makes practical sense.

As discussed, anti-radiation passive shields may include structures made of known and effective radiation-shielding materials. Aluminum; polyethylene; boron nitride nanotubes; and kevlar; are other known good radiation shields. Surprisingly, aluminum, a traditional material used in spacecraft, provides moderate protection. But, aluminum has a great disadvantage that it may release high energy particles as it gets struck by high energy cosmic rays. Polyethylene has a high hydrogen content, which makes it effective at blocking cosmic radiation. Boron Nitride Nanotubes is strong and thermally stable, with potential for structural use and radiation shielding. Finally, Kevlar, known for its strength and ability to attenuate harmful radiation, may prove to be an adequate radiation shield in space.

[2b]. Active anti-radiation.

Although there have been some significant advances with passive radiation shielding, there have seemingly been slow and scant advances developing reliable and feasible active radiation shields. Especially when considering spacecraft-scale shielding. The energy required to generate a magnetic field that is significant-enough to provide adequate cosmic radiation shielding; is enormous. Superconducting electro-magnets may be used. But, superconductivity has its array of unsolved challenges, especially for interstellar mission design. Although, I must add, the cold temperatures required by superconductivity are aided by the already bone-chilling temperatures of most of space. And, there are the so-called “high temperature superconductors”, that include Yttrium barium copper oxide, which can achieve superconductivity at about 9 degrees K, or -181 degrees C.

However, the super strong magnetic fields required to deflect cosmic radiation require large amounts of energy. For example, it is estimated that 0.1 Tesla of magnetic force might be needed to shield a crew within a Space-shuttle-sized spacecraft. That field may require continuous electrical currents; in the order of hundreds of kilowatts. For perspective, on average, one U.S. household consumes about 1.2 kilowatts of continuous electrical current per year. So, an interstellar craft’s active anti-shielding system would hypothetically need, at-least, the energy required by an entire neighborhood; in a continuous basis. This type of energy generation requirement, using our current technology, would require big and heavy power generators. And, for interstellar treks, the idea of solar

energy must be thrown “out-of-the-window”. Nuclear energy is all we have, so imagine lifting a full sized nuclear reactor facility from earth to space. This is currently a complete and utter fantasy.

Predictably, no significant anti-radiation system, passive or active, have been built for any deep-space craft. This is due to the scale and complexity required, among other roadblocks. These capabilities, again, are just outside of our current building capacity. And, this is just considering the needs for a single starbound spacecraft; nevermind our ability to equip a fleet of ships.

Although we have access to many of the materials necessary to build shields for an interstellar mission; the sheer scale at which this is required, is just too much for us at the time. Although, seemingly, there are hopeful advances in our power generation capabilities; using nuclear fusion. This capability may greatly enhance our chances of building active anti-radiation systems. But as of now, this requires an extremely large mass of equipment, very exotic technologies, rare materials, and massive amounts of energy. And, we are just unable, currently, to deploy these to space. Sadly, with our current pace of development in many aspects; these required anti-radiation systems remain challenges that may stay out of our reach for decades, if not centuries, to come.

[3]. Artificial gravity systems.

Low gravity presents a wide array of problems for the human body and the design of an interstellar mission. As you may know, your body is acutely attuned to be healthy at precisely “one earth gravity”, 1-G. Anything outside of this will likely have an adverse effect on human health. Muscle atrophy; bone density loss; body fluid redistribution; cardiovascular changes; motion sickness; immune system suppression; and psychological effects; are but a few of the known problems low gravity brings. For example, astronauts have been known to lose about 2% of muscle and bone density, per month, during extended stays in space. And, these are generally highly-selected and top-health individuals.

On any space mission, especially interstellar missions; we must offset these ill effects, from low gravity. Better yet, we should “prevent” these ill effects. One method is by generating “artificial gravity”. Centrifugal force, by a spinning motion, is a relatively simple way to generate gravity. But,

the “scale” of the system to carry out this simple job, safely and comfortably, is a gargantuan challenge. To generate centrifugal force gravity at the “kilometer-scale” is wholly outside of our current building capacity. For example, for a ring-like structure to provide 1G, at a comfortable 1 revolution per minute, it would need to be 3.5 kilometers in diameter!

Smaller, local centrifugal force gravity machines can replace the need for these gigantic structures. With these, astronauts would get a sort of “gravity treatment” for a certain period each day. But, these create, as of yet, unsolved problems such as motion sickness, vertigo, and coordination problems. And, this “treatment” needs to be painfully long, lasting over 1-hour per session.

Additionally, the effects of acceleration, especially those to relativistic speeds, are utterly unknown areas of space flight. However, the acceleration of a spacecraft at 9.31 meters per second squared may generate artificial 1G gravity as a result. But, such acceleration and its energy requirement, is utterly out of reach; currently. For example, for a spacecraft to only reach 20% of the speed of light, about 1.72 meters per second squared acceleration is required. And, still, even this is a current impossibility.

Although a gargantuan challenge, artificial gravity is likely to be a problem that can be solved with current technology. I believe that we currently possess the energy, propulsion, and materials required to build a kilometer-scale torus structure that can provide stable 1-G gravity. The main challenges that prevent this are the lack of the necessary world space program, cooperation, and the “earth to LEO” payload-capacity; necessary to build such structures on earth’s orbit.

[4]. Orbital ship-building megastructures.

Due to earth’s strong gravity pull, accessing space requires a lot of speed. This speed requires plenty of thrust. And, these combined require unbelievable amounts of energy. For example, just to reach low earth orbit, LEO, a mere 160 km, a rocket needs to reach a speed of about 9.4 km per second, 33,840 km per hour; and spend about 1.6 million kg of propellant. That is about 288 terajoules of energy!

This method, to access space, is wholly inadequate for any interstellar mission. Given these, the energies required for any starbound-sized ship, to go from earth to LEO; are just unthinkable. So, building and launching spaceships from earth orbit is absolutely necessary.

I believe that orbital ship-building mega-structures are necessary to build ships in earth's orbit. As the ability to spacecraft in orbit requires unthinkable amounts of infrastructure and resources. These mega-structures would allow the in-orbit, low gravity assembly (or construction); of the spacecraft required for an interstellar mission. And, it would be a "rally-point" for the construction crew, managers, and the on-site equipment necessary for such undertaking. The building of such a structure would be a gargantuan project of its own. And, it would be expected to process a constant supply of materials required for ship building. Presumably, most of the materials and supplies would be sourced from earth and the moon. So this megastructure would act as a "hub" for a near-constant inbound-and-outbound traffic of spacecraft. Needless to say, the construction of this megastructure would be one, or perhaps, the most expensive and colossal undertaking in human history!

The building materials necessary to build a single interstellar spacecraft would have to be rocketed mostly from the earth's surface onto the orbital structure; incrementally. For this, a fleet of powerful and capable ferrying earth-based spacecraft are absolutely necessary. Something we currently utterly lack. And, each spacecraft payload capacity would have to dwarf that of our heaviest-lifter yet; the Saturn 5. And, a worldwide cooperation for such undertaking will be most certainly required.

Unfortunately, currently; we utterly lack the rocket availability: the global cooperation; the energy capacity; the material and its logistics organization; the necessary infrastructure; (let alone) the global space program necessary to engage in building an interstellar shipbuilding orbiting structure.

First, we currently have about a dozen weak and inadequate rockets from NASA, Space X, and other space agencies and companies. Second, we are in conflict, strife and contention among nations. With secrecy, separation, hostility and protectionism, trumping over the necessary cooperation for the design and construction of a mammoth project, such as the one required for interstellar ship building. Third, our energy capacity barely covers our needs to survive, be healthy, produce, and feel comfort. Our energy production capacity is merely geared to make a few corporations some pathetic and

temporary profits; thus constantly running on bare bones. Simply put, our current energy production capacity is too puny to expand it into earth's orbit with any significance. Fourth, largely, our material logistics capabilities are stagnant, with focus on nations fighting each other. So, it is nearly hopeless that the necessary massive investment will be made, and the necessary diminishing of military budgets, in order to begin ballooning our earth-to-orbit logistics capacity. Finally, our earth-to-orbit infrastructures, world wide, would need to multiply many-fold from current quantities. For this, the world space program and cooperation necessary would have to be in place. Forget working alone! As proven for the last 5 decades, NASA and all other space programs (CNSA, ESA, UAESA, ISRO); have only strenuously puffed-out tiny unpiloted probes, taking pretty photos around our solar system. And, have sent a few hundred people into earth-orbit and the moon. So, I believe, unification and cooperation is absolutely necessary to achieve interstellar flight; beginning with building an in-orbit ship-building structure.

[5]. Space particle shield systems.

Space particles are sparse and mostly smaller than dust size through the known universe. However, there is larger space debris that can cause serious damage to spacecraft at high speeds of travel. Kinetic energies can be so great that the impact alone, regardless of composition of the impactor, can cause catastrophic damage. Even atomic-sized heavy-particles; may cause ship damage when these strike at relativistic speeds. Furthermore, deep space; does contain micrometeoroids and larger particles, although they are quite sparse. And, while traveling at high-speeds; these denser areas of space may be difficult to avoid. There may be zones, in outer space, perhaps undetected, that are densely-packed with heavenly bodies, such as our solar system's asteroid belt and oort cloud. These may exist as rogue pockets in interstellar space, or in zones as we approach the destination star system. Back in our solar system, space debris impacts are more likely. This is especially true on the many required trips to and from LEO. This is due to the growing amount of "space junk" orbiting earth. And, if space becomes the next battleground, as many not-so-bright people would rather have it; space junk could ground all space travel. As an interstellar craft speeds-up to serious amounts, turning and weaving through space debris; is almost a comical idea. The energies and navigation complexity required to fly around planetesimals, asteroids, and other heavenly bodies; will likely be prohibitive.

Again, this is especially true if significant percentages of relativistic speeds are reached. For this, I believe we need systems on board that detect, block, or destroy any damage-causing particles; the ship encounters in its path. Obviously, we cannot depend on our natural sensors during navigation on earth; sight, hearing, magnetism, etc.

Interstellar space is hauntingly dark, largely airless, and the speeds that will likely be involved; render most use of sight useless for navigation. So, ultra-advanced particle-detection and neutralization systems need to be developed for interstellar travel.

Like radiation protection, particle shields may be passive or active. Simple physical shields may be used as passive protection. Relying on massive, sturdy, and dense structures in front of the ship, that can block, deflect, and or absorb impacts in outer space. And, active shields can employ advanced lasers or other beamed energy, and zap particles out of existence, well ahead of a possible impact. Also, active shields may involve some sort of force field that deflect particles.

I believe it is excessive to say that; space particle impact shielding systems for deep space craft is a wholly undeveloped field. I believe these technologies are non-existent on any seriously-planned or built spacecraft. And, there are reasons for this. Again, this goes back to our current energy producing capability, and our anemic general manufacturing capacity, including in orbit.

This unsolved problem, of space particle shielding, is made much more simple if we decide to embark for the stars using slow technologies. But, if the problem of reaching significant degrees of the speed of light is solved; the work on this field would necessarily become a high priority. There are some proposed systems which involve large physical shields placed in front of the direction of travel of the spacecraft. For example, an artificially-generated dust cloud in front of the proposed Daedalus Project’s interstellar ship . Materials, size, and shape choices would largely be determined by many mission, technology, manufacturing, and resource factors. Again, laser gun type concepts remain attractive methods to protect against high speed impacts. Especially the idea for the laser (or lasers) to vaporize incoming larger particles and debris well ahead of the ship. But, I believe the energy source, and the ultra-advanced detection and targeting technologies required for these concepts are, at-best, still undeveloped.

Again, at higher relativistic speeds, or higher percentages of the speed of light, debris and particle shielding become a daunting challenge. And, the theorized time-dilation around and outside of the ship only complicates matters. And possibly, particles and other bodies may strike the spacecraft from various angles. Since the ship may intercept orbiting asteroids, rogue planets, and other heavenly bodies. And, needless to say, the small size of the many possible impactors; make it a tremendous challenge to neutralize them well ahead of impact. Just imagine the precision and power needed behind a laser that can zap a dust size particle, while both the ship and the particle are moving at, say, 10% of the speed of light.

To put this mind-boggling problem aside for now; If and when we can achieve relativistic speeds with our spacecraft; Spacecraft design will have to radically change and include robust and fail-safe space particle shielding. For now, we must admit, these systems remain, almost hopelessly and utterly, out of our reach.

[6]. Space water and food sytems: harnessing, production and use.

An interstellar mission would require tons of drinking water, food, the equipment, space, materials, and supplies; to store preserve, use, and recycle their waste. And, the bulk and mass that these resources will require would be gargantuan. Not only because of the large size of the crew of an interstellar mission. But also because of the long, long, flight ahead of them. Not only these, but the crew will likely have offspring, the next generation, who will also require nurture from water and food. And, gathering water and food from destinations en route is hardly feasible, and would only further complicate and lengthen the mission by unacceptable margins.

Our technical ability at extracting water from space destinations is precisely null. And, our skills at producing food away from earth are at best in their primitive stages. So, the problems presented by our need for water and food, in space, are tremendous; to put it mildly.

It is estimated that the water required for a 40 year space voyage for a crew of six; would be from 44 to 175 metric tons, depending on a 90 percent recycling efficiency and on water use restrictions from limited to moderate. Forty years, of course, is likely not enough time to complete a voyage to Alpha Centauri, with current propulsion. So, the water mass required in reality would be many times this amount. But even considering this amount, up to 175 metric tons; brings swift doubts to any plans for interstellar travel. Recall that our best and largest rockets can’t lift more than around 50 metric tons of total payload. So, the figures bring hopelessness when we consider the true requirement, for water alone, for a small crew on a deep space mission. If we were able to mine water from the moon or other solar system bodies; the task of lifting it from earth would be alleviated, but the mission would become magnitudes more costly and complicated. And, time would be added to the voyage. a lot more time.

Also, it must be considered that water requires bulky and heavy storage tanks, and complex and bulky systems to harness it, treat it, recycle it, and dispense it. Water in space also needs to remain warm so it can stay liquid. And, space is bone chilling cold. Heating water is energy intensive, and energy is an expensive resource away from our or any other sun. Although water may double as a radiation shield, it must be pumped and kept stored around the living areas of the crew; a complex and resource intensive task. For this, containers need to remain water tight and heated at all times, consuming resources and energy every hour of the mission. Sadly, we utterly lack the propulsion and payload capacity to get the amount of water needed to space. And, we lack the advanced storage systems to store the water even if we got it to space. And although we have some experience recycling water, our recycling efficiency is not enough to limit the water amount needed for long voyages. Lastly, we lack the technology and experience in harnessing water from space or other heavenly bodies.

It is estimated that a round trip to Alpha Centauri, for a crew of 6, at 10% of the speed of light; the crew would require at least 330 metric tons of food. That is without including the systems and equipment to maintain such food, or safety margins. Obviously, lifting this amount of food to low earth orbit is a daunting challenge; using current technology. Imagine the challenge of transporting this mass to another star system, and preserving much of it throughout the voyage. Even if somehow we figured out how to farm and grow food “en route”; this would take a ridiculous amount of space, resources, and additional special equipment. And, all earth based food requires solar energy, something that will be extremely limited during most of the trip. Also, food growing and farming requires gravity; a challenge yet to be solved.

First, the time required to travel to Alpha Centauri makes it prohibitive to even plan on the food required for the trip. As of now, it can take from hundreds to thousands of years to complete the voyage. So, obviously, we simply cannot plan on taking all of the food needed. Instead, we would need the technology, environment, and skill to grow, harvest, and consume our food “en route”. Gravity should be a solved problem. Simply put, all that grows on earth needs earth gravity, and trying to go around this requirement is simply dangerous. Also, solar radiation is necessary. We need to provide this radiation from our sun, or another star somehow, or closely duplicate it. For this, vast arrays of advanced radiating sources need to be in place, and a room with a few lights just won’t do it. And, contrary to depictions in sci-fi media, a room with a few pots with plants, and some cages with some farm animals just won’t work. The ship, or ark, would require vast open areas for fields of food, much like those on earth. And, gigantic farms for all types of animals to grow. Sadly, eating crickets and rabbits for meat, for over 100 years of travel, will get very aggravating and demoralizing for the crew. And, a limited variety of fruits and vegetables will do the same. The crew, even a small crew of 6, needs a wide variety of earth-like foods. I believe the difference between earth and space grown food; cannot be detectable, for such a long period of voyage to succeed. Food farming and growing are still in their infancy, and although some foods have been grown in space, their taste and consistency just isn't the same. And, large scale food growing has not occurred in space.

Ultimately, we must admit our delayed state of advancement in the area of water harnessing, storage, and use in space. As we must recognize our “infant state” of food growing, storage, and use in long duration

space habitation. We must solve problems of gravity and radiation, and be able to lift more mass, and build larger ships. Until then, any talk on interstellar travel is just hypothetical and wishful.

[7] Gigapower sources.

[7a]. gigawatt scale solar power source.

As discussed, building a spaceship in orbit is an incredibly energy-intensive process. The energy required may depend on several factors: the mass of the spaceship built; the number of crafts to be built; the altitude of the orbiting structure; the velocity needed to maintain that orbit; among others. The earth-based energy requirements, to maintain such orbiting structures staffed and supplied, would be immense. And, the materials and energy source required by the star-bound craft, or crafts, would necessitate yet-to-be-imagined energy-generation capacity.

Apart from providing the tiny power required by our current space-based craft, humanity has not delved into “serious” space-based energy production. We have powered our puny probes and the ISS largely with a few thousand watts of solar energy. And, some have been powered with miniature nuclear reactors. But, orders-of-magnitude more-energy, will be necessary for orbital interstellar ship construction; the ship’s propulsion; anti-collision; gravity production; among other power-hungry systems.

Solar-energy, many may say, is the obvious option; opening the possibility of almost uninterrupted harnessing of power. The ISS is our largest structure in space at the moment, and the producer of the most space-based energy. It has a photovoltaic array spanning 2500 square meters, with a power capacity of about 240 kilowatts maximum. Many of our largest, earth-based solar energy farms, which take hundreds of hectares of land and millions of solar modules; are rated in the hundreds of megawatts, hundreds of millions of watts. But, the energy requirement, just to build one interstellar

ship-building megastructure, and at-least one ship; may be in the gigawatt scale. That is over several thousand megawatts!

[7a] gigawatt scale non-solar power source.

Although solar energy is a tempting option to build earth and earth-orbit based infrastructure; we have a major problem with depending on solar energy for interstellar flight. The star-bound spacecraft will have to depend on increasingly-insignificant star radiation as it speeds away from our sun.

You may know that, with our current solar energy efficiency of less than 30%, harnessed solar energy becomes increasingly weak, as near as the orbit of mars. So, anything past our asteroid belt requires a non-solar power source; if serious power is a requirement.

Also, Nuclear fission is currently inadequate for propulsion, as discussed earlier. And fusion remains a promising, but yet not fully-developed energy production technology. So as of now, all we have is the weak solar energy, slow and inefficient chemical-based rocket energy, and the complex, heavy, and bulky nuclear fission. These are barely-okay for ship-building on earth's orbit, but are wholly-pathetic for the serious power-requirements of starship systems; such as propulsion. For this, massively powerful onboard energy generators, of some sorts, are necessary. Able to produce fuel for propulsion and other systems, real-time; to be used as needed. These energy generators will necessarily need to extract its fuel from the space medium. This is extraordinarily hard with current available technology. Just imagine attempting to collect any fuel from the extraordinarily empty and airless outer space. And, there is not much fuel to gather from open space, perhaps hydrogen which needs to be collected in massive amounts; for it to be of any use. Nuclear fission requires a lot of water for cooling, a rare and bulky resource for use in outer space.

Alternatively, fuel for energy may be collected from installed waypoints between celestial bodies. But, this capability must necessarily be much more advanced than our, currently null, ability to go to another star.

Ultimately, we lack the non-solar energy source that would propel us to the stars in a reasonable time. And short of a huge breakthrough with nuclear fusion, hopes are low, to come up with such source. Alternatively, we may opt for slow, centuries long travel times, and stick with our current rocket power. Perhaps rocket efficiencies may dramatically improve, and we should expect the crew to be capable of improving and learning at a fast pace. Perhaps, improvements and modifications to the propulsion system can be made en-route, and “speed-up” the journey; considerably.

[8]. Autonomous robotics and computing.

Amazing advancements have clearly taken place, in the fields of robotics and computing, over the last few decades. And, recently there have been many gains in machine autonomy and artificial intelligence, AI. However, I believe that the level of autonomy and prescription, required for a successful interstellar mission, still lay well ahead of us. For example, all kinds of navigational decisions would have to be made, in real time, many-times-faster than any human can handle. To avert problems with the ship, or avoid physical threats while en-route. Such as if laser shield systems are used to vaporize incoming micrometeors; and performing safe adjustments to speed and direction at relativistic travel speeds. Like current large and complex systems on earth; interstellar ship systems will likely be so complex and in such a scale that error-prone human intervention may be dangerous. So, relegation to advanced autonomous systems may be a prerequisite to crewed interstellar space flight. But, the systems for the AI to control are yet to be developed, so it is like to say that “the horse still needs its carriage”.

[9]. Space medicine.

[9a]. Genetic enhancement.

Human genetic manipulation and enhancement are currently controversial and unethical practices in most of our societies. Although, I believe we are inching into changing this. From cancer gene manipulation, to physical appearance gene manipulation, I believe these are becoming more accepted practices. Body enhancements, through surgery, have been practiced for many decades now. From prosthetics to plastic surgery, humans have changed themselves by artificial means, and it certainly is a more-desired and accepted practice than in the past. This attitude may aid the change in the acceptance of “prenatal gene manipulation”, for the partial “design” of certain traits and abilities of future humans. I, personally, see the practice as abhorrent; presenting a risky precedent. But others clearly don’t. And, I don’t believe we must change our “genetic make-up” to “withstand” the lack-of-gravity and the high radiation, for example. I hold the attitude that, “we should shield and remove these factors from our environment; go to earth-like destinations; or don’t go at all”.

[9b]. Life extension systems and synthetic organs.

In a long duration space trip, such as for an interstellar mission, there will have to be some serious advances in space medicine. Especially since any interstellar mission, currently, is likely to be a “cast-away” one-way mission. The ship will eventually, perhaps very quickly, have to assume its own independent “command” and become completely autonomous. Because of this, space medicine on board needs the capability to take care of “all” of the medical needs that exist, and that may arise en-route. Many of these medical needs will include completely-new health problems, illnesses, diseases, and syndromes. And, an incredibly-fast and capable, perhaps AI-based, medical team will have to be on-call all hours of the day, and new problems will have to be dealt with aggressively due to the likely

“close-quarters” of the spaceship human environment. And, with the continued possibility of rapid disease mutation, and animal-to-human virus transmission; animal health will have to be closely-watched.

Also, Space-based birth rates will have to be restricted and highly-managed. That will likely mean low birthrates, which may translate to the need to extend life as much as possible. Births may have to be managed in such a way to enable higher brain capacity, meaning larger heads, larger birth canals, or routine cesarean births. This may be a decision to be made by the crew, depending if “human command” is to be maintained; as opposed to “AI command”.

Space medicine, in the fields of synthetic organs and limbs, may develop rapidly due to its onboard critical necessity. Due to the tight quarters and low population on board, there will likely be a major need to have “all onboard” be as productive individuals as possible. Necessitating near-100% functioning of bodily systems. So, if limbs and organs are injured beyond healing, or fail because of disease or other reasons; synthetic replacement may be highly desired. This is occurring on earth, so I envision the rapid expansion of this due to the needs on board an interstellar mission. Also, multi-purpose genetic manipulation, to improve limp and organ regeneration may expand on board. Survival in space may become a high priority, and this perhaps may render as “undesired” many of our “abhorrent traits” carried from earth. And, genetic manipulation “nulling-out” those traits; may become accepted.

Although we have advanced significantly in medicine on earth; robotic prosthetics; organ transplants; genetic manipulation, and more. I believe, we need many more advances, to bring up the reliability of the human life-extension and enhancement systems; necessary for interstellar readiness.

[9c]. microbial and non human biology management.

As discussed, microbes and bacteria grow and evolve rapidly in low gravity. These may threaten the health of an interstellar voyage crew. Even neutral and friendly bacteria that live in our bodies may evolve to forms that may harm us. So, the close “monitoring and control” of these organisms are crucial for mission safety. Systems that can help with this monitoring and control are necessary, and require a high level of advanced systems, those that can automatically track genetic mutations, for example. And, although very advanced from our earthly perspective; medicine has vast limitations on this front. And, although we have made strides in advances in space medicine, thanks to the efforts on the ISS, I believe those have been “a drop in the bucket”. I say this because long duration space voyages would expectantly-bring magnitudes-more of these types of challenges. Also, many new and unknown problems may arise while en route; dealing with spaceship biology. And, advanced systems and methods may have to be developed, literally, on the fly; to quickly deal with these problems. Fast-acting AI systems that far outpace human capacity will likely be needed. As of now, our current systems of space organism control are simply not where they need to be. And, are necessarily-limited by our low-experience with deepspace long-duration habitation.

[9d]. Human procreation management systems.

Unlike on earth, interstellar missions will bring many challenges with human procreation. Apart from the well-known and still-unsolved problems with high-radiation and low-gravity; there is the issue of low occupancy space, and dwindling resources, onboard. Even a large generational ark would need to keep strict controls on birth rates, and the quality of the nurture of every individual.

These and other “human population requirements” will call-for systems, methods, and equipment; much-more advanced than what we have ever produced. For example, not only will we need advanced systems for blocking radiation, and producing gravity. Which will have to be in place before any talk on procreation. But there will be the need for the ultra-advanced medical facilities,

personnel, and resources to facilitate the delicate business of en-route space-based human birth. This realm of biology is utterly uncharted territory, as per my knowledge and research. And, will absolutely have to be a nearly fail-safe affair, a non-issue, a solved problem; for long duration interstellar flight to get the “go ahead”. And, after birth, the strict controls on the upbringing of each individual; would have to be in place, and highly enforced. Again, these strict standards are necessary due to the unbelievably challenging environment of space; the nature of the limits in the spacecraft or ark; among the other challenges talked about previously.

From an earthly perspective; these tight controls, ultra-advanced monitoring systems, and strict human birth and upbringing requirements; may be seen as overly demanding and manipulating. But, I believe they are definitely-necessary to ensure the well-being of all on-board, and the success of the mission. And, the remaining “questions” around human procreation, in space, need to be settled; long prior to developing these necessary systems.

Section 3.

The Human Factor.

Introduction.

The most challenging problem with human interstellar travel is its “human” component. I strongly believe that interstellar travel would have been a reality, many decades ago, if it wasn’t for our recurring “dream” of taking ourselves along to the stars. Humans are demanding, delicate, unpredictable, and vulnerable living organisms; that require too many resources for nurture. Humans need a constant supply of breathing air, massive amounts of water and food, in addition to the nagging requirements of space, socialization, and medical attention. All these “needs”; require a stupendous amount of energy spent on infrastructure, payload to LEO, and unspeakable “extra” technical and material requirements.

All these human-caused “requirements” add costly weight and bulk to the already critically-limited payloads; to be lifted via rocket. And, these add to the already critical mass onboard; to be somehow propelled across the vast distances between the stars. Additionally, NASA’s 5 hazards of human spaceflight, not only apply for interstellar flight, but are exacerbated by at least multiple orders of magnitude. In the context of interstellar flight, suddenly, the seemingly solvable problems of radiation, gravity, isolation and hazardous environments; become almost hopeless enigmas.

Forget the often-portrayed ability of human “animated suspension”, and the utilization of “warp drives” or “worm holes”. Sadly, Superman is not coming, in the case of interstellar travel. These scenarios are, and will likely remain, the stuff of science fiction. Freezing humans like poultry meat, or machines that generate artificial gravity, like if you’re wearing magnetic shoes; are just comical jokes in scientific circles. And, any other more realistic means to solve these problems, remain “at best”

undeveloped. Ultimately, to put it mildly, the many problems introduced by the “human factor”, will be much more challenging in an interstellar mission.

But, putting aside the gargantuan technical hurdles with putting humans in pickle jars, and shipping them off to the stars, and focusing on the actual challenges; we may discuss these 5 challenges. So for now, let’s ignore the fact that, exclusively-machine missions; suddenly remove most barriers to interstellar travel.

Again, it helps to look at these challenges by listing them as they relate to NASA’s 5 hazards of space flight. Here, I will call them the 5 challenges of human interstellar travel, and they include: Radiation, gravity, isolation, distance from earth, and closed hostile environments.

Cosmic radiation becomes a tremendously bigger problem in interstellar flight. Due to the unimaginably-longer travel periods, the blinding-speeds likely required, and the distance to be travelled. These alone exacerbate the situation many fold. The lack of gravity remains an issue for interstellar flight. Both, radiation and gravity must be “solved problems” for the health of the human crew and their possible en-route descendants.

Our distance from earth, the planet where our biology and psychology evolved, will be lost in the rear view. At this sight, humans will necessarily change and begin to adapt to whatever environment they will inhabit; for perhaps centuries. This change will depend on too many factors to list here. But one thing is certain, change will occur. And, we should expect that not all changes will be advantageous. For example, initial changes may be unexpected and chaotic, even hostile. Some in the crew may respond to drastic changes, with violence. If so, how will these cases be handled?

Our ability to procreate in space is at best unknown, at worst is utterly unsafe and harmful for both the mother and the child. Our bodies don’t like space. The lack of gravity, and the hopeless lack of

suitable air; are punishing truths we must accept. I believe an earthlike destination will be very hard to find within a few light years from earth. The challenges with human isolation, on a spacecraft, remain thorny and unsolved problems. And, of course, these become colossal problems for interstellar crews.

Human psychology is quite fragile, and human interaction is volatile. In many instances humans revert to jealousy, anger, hostility, envy, hatred, and other damaging behaviors. These are ingrained in us, and are likely to remain part of our lives foreseeably. Curiously, life would probably be a boring stage without them. And, to my knowledge, no human crew has been able to work peacefully and harmoniously, for any space-related project, for periods over 1 year. So, the effects that closed environments will have on the human crew, and the effects those humans will have on the mission; is at best “not known”.

Further hurdles with interstellar travel involve agreements in human interaction. There may be many civic and ethical questions in an interstellar voyage, as it will likely be, or become, autonomous or sovereign. I believe interstellar voyages will likely, eventually, be independent from any nation on earth. So, questions of the form of command or government will have to be answered. For example: which will be the encouraged or discouraged, or dominant; cultural, social, or religious systems? Will racial, ethnic, and behavioral differences be an issue? Also, there may be ethical problems with recruiting, education topics, among others; as there are currently on earth. What should be the default spoken language on board? Who should be in management or command positions, and why? Also, there may arise human factors that are damaging to command and hierarchies, specific to long duration space travel; causing turmoil or mutiny.

At best, many decades into our future and if all these problems are solved; we may have a shot at visiting another star system with humans onboard. But, things may be a lot different than what we would commonly expect. Humans may not be in charge, perhaps relegating, or having been demoted;

to a position of mere spectators. Relics, carried along, on a trip designed and executed by ultra advanced machines. Our past abilities, long ago, having been passed on to advanced machines.

Other possibilities include traveling to the stars only as information. The fragility of human biology and psychology may be the things that keep us from traveling to other stars. But, machines may be used to send our information to the stars in the form of nearly-indestructible data; to be decoded at the destination by machines. Or, humans may travel to the stars as DNA. And, machines would grow humans at the destination; bypassing the need to nurture fully developed, or developing; human bodies. Ultimately, I believe our trip to the stars must start with a single question. Why?

So, without further ado, here is my final chapter on this series, Challenges of Interstellar Travel: “The Human Factor”.

See recordings of 08 Jan 2025, on this topic (transcribed from audio recording).

Section three.

The human factor - introduction.

The most challenging problem with human interstellar travel is its human component. I strongly believe that interstellar travel would have been a reality many decades ago if it wasn't for our recurring dream of taking ourselves along to the stars. humans are demanding, delicate, unpredictable and vulnerable living organisms, that require too many resources for nurture. humans need a constant supply of breathing air, massive amounts of water and food, in addition to the nagging requirements of interpersonal socialization and medical attention. all these needs require a stupendous amount of energy spent on infrastructure, payload to LEO, and unspeakable technical and material support. all these human-generated requirements; add unwanted weight and bulk to the precious payload lifted via

rocket. and add mass to the already critical payloads to be propelled from earth and across the vast distances between the stars. Additionally, NASA's five hazards of human space flight, not only apply for interstellar flight, but are exacerbated by at least multiple orders of magnitude. in the context of interstellar flight, suddenly, the seemingly solvable problems of radiation, gravity, isolation and hazardous environments; become almost hopeless enigmas. You can forget the often portrayed ability of human suspended animation, and the utilization of warp drives or wormholes. Sadly Superman is not coming; to help in our efforts in interstellar travel. these scenarios are, and will likely remain, the stuff of science fiction. Such as freezing humans like poultry meat, or deploying machines that generate artificial gravity; or else use magnetic shoes. These are just comical jokes in scientific circles, and any other more realistic means to solve these problems; remain at best undeveloped.

Ultimately, to put it in mild terms, the many problems introduced by “the human factor” will be much more challenging in a real interstellar mission. Evn when putting aside the gargantuan technical hurdles in the business of “putting humans in pickle jars” and shipping them off to the stars, and focusing on the actual challenges; we still must face NASA’s five hazards. So here, I discuss these hazards of space flight, Ignoring the fact that “exclusively machine missions” remove most of those and the other barriers to human interstellar travel. Again, it helps to look at these challenges by adressing them as they relate to NASA's five hazards of space flight. Here, I will call them the five challenges of human interstellar travel. they include: radiation, gravity, isolation, distance from Earth, and closed hostile environments. cosmic radiation becomes a tremendously bigger problem in interstellar flight, due to the unimaginably longer travel periods, the blinding speeds likely required, and the distance to be traveled. these alone exacerbate the situation many fold. And, the lack of gravity remains an issue for interstellar flight. And both radiation and gravity must be solved problems for the health of the human crew and their possible end-route descendants. Additionally, our distance from

Earth, the planet where our biology and psychology evolved, will be lost in the rear view. at this sight, humans will necessarily change, then must begin to adapt to whatever environment they will inhabit for perhaps centuries. this change will depend on too many factors to exaust here, but one thing is certain, change will occur. and we should expect that not all changes will be advantageous. for example, initial changes may be unexpected and chaotic, even hostile. some in the crew may respond to drastic changes with hostility and violence, and if so; how will these cases be handled? In addition to other challenges, our ability to procreate in space is at best unknown, at worst; utterly unsafe and harmful for both the mother and the child. our bodies don't seem to like space, and of course, the lack of gravity and the hopeless lack of suitable air; are punishing problems we must accept are still unsolved. i believe an earthlike destination will be very unlikely to find, especially within a few light years from Earth. And, the challenges with human isolation, on any type of spacecraft, remain thorny and unsolved problems we must address. And of course, these issues become colossal problems when thinking of interstellar crews. As we've found over the decades of study, human psychology is quite fragile, and human interaction is volatile in many instances.

Humans tend to easily revert to jealousy, anger, hostility, envy, hatred, and other behaviors damaging to tight quarters habitation. these traits are ingrained in us, and are likely to remain part of our lives foreseeably. curiously life would probably be a monotonous stage without at least some of these, and to my knowledge no human crew has been able to work peacefully and harmoniously; for any space related project of long periods. So the effects that "closed environments" will have on the human crew, and the effects those humans will have on the overall mission; is at best not known. further hurdles with interstellar travel involve human agreements and interaction. there exists many civic and ethical questions, still unanswered, for an interstellar voyage. as any star bound crew will likely be or eventually become autonomous or sovereign. i believe interstellar voyages will likely

become independent from any nation on earth. so questions of the form of command or government; will have to be answered prior to departure. for example, which will be the encouraged or discouraged or dominant cultural social or religious system?; will racial ethnic and behavioral differences be an issue? Will a conventional pyramid style rank system be maintained? Also, there may be many ethical problems to sort out. Such as with recruiting, education topics, and sexual, social and politial orientation; among others. These are likely to be as controversial as there are currently on Earth. Also, what should be the default spoken language on board?; who should be in management or command positions and why? Also, there may arise human factors issues that are damaging to command and hierarchies, specific to long duration space travel, which cause turmoil or even mutiny.

at best, many decades into our future, and if most of these problems are solved; we may have a shot at visiting another star system, with humans on board. But, things may be a lot different than what we would commonly expect. humans may not be in charge, perhaps relegating “the heavy lifting to machines”. Or, having been demoted by machines; to positions of mere spectators. Relics, carried along on a trip designed and executed by ultra advanced automated systems, with our past abilities long ago having decayed; and hopefully relayed to advanced systems.

other possibilities include; traveling to the stars only as information. the fragility of human biology and psychology; may be the things that keep us from traveling to other stars, but machines may be used to send our information to the stars, in the form of nearly indestructible data, to be decoded at the destination. Or, humans may travel to the stars as protected DNA, where machines would later “grow humans” at the destination, bypassing the difficulties with nurturing developed human bodies. Ultimately, I believe our trip to the stars must start with a single question: why?

So, without further ado, here is my final chapter on this series: challenges of interstellar travel “the human factor”.

The challenges of interstellar travel - the human factor. transcribed from a January audio recording.

Any foray into space, especially into outer space is, needless to say; a difficult and challenging undertaking. But, the challenges multiply, when you add humans to the mix, to these space missions. adding crews, human crews, to space missions; multiply mission difficulties by orders of magnitude. And, more than we usually like to admit, the human body is a fragile and delicate organism. One that requires a lot of maintenance, a lot of care, and technology working for its comfort, its well-being and its upkeep; constantly. just think of your last long trip, or vacation, or visit to a far away place from home. Think of the amount of supplies, resources, materials, luggage that you have to take with you. to keep your comfort, keep your health, and maintain your familiar routines. Especially when it comes to everything that you must do, during the day, during your active hours, during sleep, etc. also, think about the food and the water, or liquids that you consume during that time, during the trip. the amount of food that you may take with you, and the amount of food that you may acquire, or purchase during the trip. many of us, may also need attention, such as social care, social interaction with others. Also, we need activity, when it comes to exercise, bodily activity is important. And, also intellectual or brain activity. As we need to keep busy, to keep our mental and body health up. many of us, also, need medical attention; in the form of medicine, and checkups. Routine checkups of current health conditions, for examople, are at times necessary for many people. Also, our mental health has many requirements. it needs socialization, it likely needs some sort of spirituality, hope, goals, purpose, explanations. it needs to explain to itself; many things around it. it needs to justify our actions, justify efforts. it needs to be satisfied with its lifestyle, its surroundings, the achievements that we have made. our psychological health is a huge consumer of resources and energy, so we as humans, require a tremendous amount of many types of resources. These may come in the form of bulk, weight, baggage. it takes up a lot of space, a lot of energy again, and a lot of resource in the form of funds, or monetary

resources, money. And, Our psychology also requires the support of other people, technology, systems and methods. all these surround a single human being, let alone the requirement of an entire group of humans; such as a spacebound crew of astronauts. Of course, in a space voyage, even a single human would require much more resources than the average human here on Earth. think of your imaginary long trip again. Where you'd be going to a destination here on Earth. you need to take all of the things needed; luggage, equipment, all of the food and drink; you expect to use, during and after the trip. And, when we're talking about spacebound crews, these same resources must multiply many fold. Largely because the trip time expectation, to be out in space, is a lot. usually a much longer than the longest trip you can think of; on Earth. especially when we talk about deep space travel. and unlike here on Earth, where you can gather things from your surroundings as you go, for example; en-route to your destination. and at your destination; you can also gather stuff that you might have forgotten. stuff that you may realize you needed, or extra stuff, to add to your margin of safety and comfort. But, in space, this is utterly impossible. you cannot just stop, somewhere along the way, and gather materials and resources that you may have forgotten on Earth. you literally "have to" take every single item you will need during your entire trip, stay at your destination, and your way back. you must take all of those items and resources with you, which can add up to immense bulk. Again, those items are for you the human, and other human crew on that space mission. which is why the "human factor" make up a very large set of challenges; for any space mission, especially that of space missions to outer space and especially interstellar missions.

So, I will organize the challenges dealing with human factors, on this program, by listing and discussing each one, as they relate to interstellar flight. of course, there are major space challenges, dealing with human factors, that match NASA's five hazards of human space flight, which also apply to interstellar travel. these five hazards are: the hazard of ionizing radiation, the hazard of changing

gravity fields, the distance from Earth, the hazard of closed and hostile environments, and lastly; the hazard of isolation. all of these hazards pose majore yet unsolved problems to human health, human well-being. so from those, I will derive the many challenges that deal with the human factor for interstellar travel. so first, to define “human factors”; they are the many situations, factors, changing and evolving situations or occurrences that have effects and consequences. These change and evolve, and are largely unpredictable, because that is part of the nature of people. we are very unpredictable in many ways. in some ways we are a lot more predictable though, biologically, for examply. Although even there, we have a lot of variation between people. But, we have even more variation psychologically, among people, and there are many health concerns, whether they are about biological health or psychological health; mental health. These bring challenges that are present here on earth, let alone on trips to space away from earth. There, these challenges may be magnitudes more severe, and significant, especially in long duration trips such as interstellar ones. just to keep it in perspective, the distances that we are talking about here, when talking about interstellar travel; are unimaginably vast. they are almost unfathomable, and well away, well removed from our everyday experiences. interstellar travel means traveling to other star systems, away from our own solar system. the closest, of course, you may know; it's the Alpha Centuri star system. and that is 4.37, I believe, light years away. and as you may know we are hopelessly incapable of reaching any degree of the speed of light, at the moment. so the trip there would take close to several thousand years, with current technology. so using current technology, we would be on a trip longer than perhaps written history. so to put it more in perspective, if you think of the Babylonians, or Sumreians, back several thousand years ago. if they were to embark on a interstellar trip, somehow, they would just now be approaching our nearest star system Alpha Centuri. And that is only if they would be using our current technology, and had somehow solved NASA’s five hazards. So, given that scenario, it would be likely that we would not be even able to communicate with that ancient crew; arriving at the Alpha Centtory system, with language

from those many thousands of years ago. at the very least, there would be a significant language barrier between the crew near Alpha Centuri and us here on Earth. Currently, again, the nearest star system to our own solar system is 277,000 astronomical units or AUs away. Again, an AU is the average distance between the Earth and our Sun, about 93 million miles, that is about 150 million kilometers (km). Also to give you even more perspective, the farthest that a small human crew has traveled to outer space, currently, is the surface of the moon. that is a mere 384 thousand km away. And, as you may know, it did take an international effort and unspeakable resources to put a few people on the surface of the moon for a very short period. so you can begin to appreciate the vast and enormous challenge that we face; to embark on a interstellar mission, even to the nearest star system; Alpha Centuri.

So, to tackle the first challenge involving radiation, space radiation or ionizing radiation. as you may have learned from my previous discussions on space radiation, from NASA's five hazards of space flight; space radiation is among the most severe problems that we have for deep space travel. Largely because it is “ionizing” radiation that we are dealing with. basically a type of radiation from space, either from other stars or from our own sun. And, basically, these are star-sourced particles, highly energetic, that are traveling nearly at the speed of light at their atomic composition. Basically, they're bare atomic cores, atoms that have been stripped of electrons, zipping around. And, these may be from havy elements such as iron, gold, silver, boron; and just about every other element on the periodic table. Which are flying around in space, and especially hazardous are the heavy elements, again those with heavy cores or atomic centers which have many protons and neutrons. Again, these can “wreak havoc” when they collide with, for example, human cells, DNA, etc. they can destroy those cells and DNA structures, and of course that causes all kinds of health issues. Whether the health problem develops right away, or over time, this is a huge problem for human health. Because, as it passes through the human body these highly energetic particles collide and rip electrons clean out of the atoms

of our own atoms, and any other material or compound that these may traverse. And these energetic particles traverse just about every material known, since they are so small and are traveling so fast. so that is probably the worst problem encountered, when taking humans along in our outer space missions. because we need to worry protecting humans, somehow, from this space radiation. Which, by the way, we have no effective and proven technologies to shield from these particles. Yes, we do have components and some methods, and technologies and materials that partly work for this task. For example, we have some materials that may block some of this radiation, but not entirely, not all. especially when we consider our current technological limitations to mass produce them, or transport them to space. such as our inability to put high payloads, high amounts of mass, into space. It is very difficult and costly, to carry weight to space. So we are limited, at the moment, on how much weight, space and size we can carry to space. we cannot carry, for example, high amounts of water. which is a known filter, or blocker of radiation. Of course not the entire amount of radiation, but a good portion, to at least slow down the damage done by this ionizing radiation. Also, materials such as lead, which is very heavy as you may know, and also very harmful to human health. however lead is effective in blocking at least a good percentage of the radiation that comes from space. But, you would need a lot of it, tons of the thing, all around the spacecraft; to significantly block a good portion of the radiation coming from all directions. i mean these particles zip about from all angles during space flight, not only in the direction opposite of travel, but from everywhere. so obviously, humans are a big complicating factor for missions to interstellar space, because of the radiation and the need to protect these humans from radiation. And that, significantly complicates the mission, and require energy and resources to that same mission. For example, shielding systems would have to be developed and built, most likely assembled bit by bit on Earth's orbit. since they would have to be very large, of colossal or kilometer scale.

These systems, again, may include “passive systems”, such as just systems that merely shield. Static systems that do not move, basically with non-moving parts, which are just there acting as a literal physical wall between you and the radiation in space. again using those materials and compounds that are known to shield some of the radiation. Or, there may be “active systems” such as magnetic, very strong and large magnetic fields; that more or less duplicate magnetic field that we have on Earth, which deflects most of these high energy fast flying particles from space. These are largely deflected before they reach our atmosphere or at least before they reach the surface of the earth. But, this is extremely difficult to duplicate, since the energy requirements would be unimaginably enormous, and the scale and the magnitude at which we need to produce, build and maintain these systems; are just utterly out of our reach at the moment.

Moving on to gravity. Low gravity has debilitating effects on the human body, therefore causing problems dealing with human factors on any space flight, let alone interstellar missions. One earth gravity is a necessity to be healthy to feel comfortable and happy, simply to survive. our body has evolved exclusively to be healthy and happy; on Earth's gravity. we call it 1G, one earth gravity, and anything outside of 1G, as I've mentioned, will be detrimental to our health. Also to our mood, to our psychological health, not only our biological health. Our hearts, our circulatory system, our nervous system, our digestive system, our bones and muscles, and just about every bodily system that we have; depends on gravity with, perhaps, very few exceptions. and the way our blood flows through our veins, even the place where our hearts are located, is a product of the many millions of years of evolution of life on earth. Of course from which life; we ourselves originated. So, the minute we step off from the surface of the earth our bodies begin to suffer and decay, and in major part because of the lower gravity out in space. This lower gravity we call microgravity. There our bodies begin to shed bone mass, bone density, as well as muscle mass, and again, our cardiovascular system begins to decay. the same occurs

with our vision, our eyes' shape and the shape of its lenses begin to deform; causing vision problems. and there are other effects in our body and our brain. So 1G gravity absolutely needs to be provided, and reliable systems that do this need to be in place. There are systems, however, that work to "offset" the effects of low gravity, and others provide gravity itself by artificial means. As of right now the only system that I'm aware of, that may provide artificial gravity (or something that feels something like gravity; are centrifugal force systems. But, again, we are limited from even these, because of the sheer scale of the structures required to comfortably and safely provide artificial gravity by centrifugal force. As mentioned, these structures would have to be enormous in dimensions, in the kilometer scale, and made with extremely durable and reliable materials and propulsion systems. Again, they would have to be kilometers in diameter, and most likely circular or taurus (donut) shaped structures, where people would inhabit the inner outside surface of the donut tube. Then this structure would have to rotate at a precise speed with little or no deviation, continuously throughout the, perhaps, millenias-long trip. and again, such construction is as of now out of reach for us on earth. we would have to be able to build those types of ships to provide gravity with no problems. Again, gravity is an absolute necessity for a long-term interstellar trip, so to move ahead with interstellar flight, this hazard needs to be eliminated.

To move on, and discuss the next human factor, specifically dealing with interstellar flight; the hazard of :distance from Earth" is critical. Among the human factors, involved with that, is that it will likely change our outlook, our attitudes, our mood, our mental health, and even our biological health. i believe, as we get away from Earth, we begin to think more independently as we adjust to autonomy. in fact, any interstellar mission, with current technology, would necessarily be a one-way trip. Allow me explain. This is because, for one, the crew will be gone for perhaps hundreds to thousands of years; with current technology. at least that long, if not longer. the crew will also travel, into space and time, in a manner most that will leave Earthlings far behind in many aspects. Especially from

communication. The communication to and from earth, will be growing in delay and gap, and eventually it will be ineffective. it will be, first, delayed by minutes. Then there will be a lag of maybe hours, and that will steadily grow to days, weeks, and so on. This will happen fast, especially, if we somehow reach any degree of the speed of light, such as with future propulsion systems. the communications delay will only grow, and be months and years in seemingly very short order. so there may be a point where communication is just ineffective and even useless. Some communications issues may depend on the conditions outside of the ship. Such the type of propulsion system used, radiation, speed, etc. There are many factors to imagine. And, just accounting for time and space, communication will be very seldom used. Limited, at the very least. And, at worst, impossible to perform. So, crews may be “cast off” into the vastness, as they leave earth. Basically, they may become an independent and autonomous crew, shortly after they leave Earth, and perhaps knowingly so. back on Earth, and the crew knowing this themselves, who are basically are a cast away or cutaway portion of humanity; to never to return or at least to never return to an earth that they would be familiar with, recognize, or be part of again. This may be frightneing prospect to many on board. Where humans, back on earth and on the ship, may evolve language to a point where they probably won't be able to communicate effectively. Because the languages on the ship, and the languages on earth, would have evolved to be incompatible, unrecognizable, not understood by both parties. just like it has throughout the millennia here on Earth. it is likely it will happen again, between the people leaving on the ship, and the people back on Earth.

Biology may also change, evolve, on the ship especially; to a degree that even if the crew were to return, they would be pretty much another species, a separate and incompatible species with humans. and this is even more so, if genetic manipulation is accepted, and occurs on the ship for the humans on board. This, perhaps, to be able to survive, or at least survive a lot better; in the hostile environment of

space. and how is biological evolution a challenge? especially a human factors challenge? Well, again the psychological stress of knowing this eventual and permanent separation. Separation from all familiar and satisfying. Especially affected may be those people that are born en route to an interstellar destination. Who may, “all of a sudden” realize that they were basically “volunteered” to a space mission away from their true home. Yes, you may argue that's what basically happens all the time, here on Earth. when you're born, for instance, you're not asked “where?” and “what parents?” you're born-to. Or, “what situation?” you're born into. So, although this logic could be applied to a crew born on board, they are still parties to an experimental space mission, without their consent, and may feel as “lab rats” of sorts. Again, “who has true consent?”, you may argue, “when they're born and about anything?”. You may continue to look at it that way, but again, the interstellar crew would be most likely on a one-way mission to whatever destination, whether it's Alpha Centaury or other star system, but the problems dealing with this realization, that you are leaving Earth for good, and that Earth is going to be utterly unreachable, ever again; would be one to affect anybody in different ways. Socially, mentally, physically, etc. So, the initial crew will most likely have psychological, behavioral and mental health issues to deal with. And those may translate to biological problems, physical health problems and illnesses, long-term and even terminal diseases; may develop eventually. not only this, but the psychological and biological human factors would not only further complicate the mission, but also add to the needed supplies of the mission. And, advanced autonomy may be required. And, all of the energy requirements all of these factors, largely because there are humans on board, are going to be magnitudes more. Consuming, resource intensive, problematic. Again, a mission without any humans on board would be a lot simpler, less costly, and more to the point of the mission. Because you would not need to “maintain” these humans and their health needs. Again, you would focus more on the goal of the mission itself, the outcome of the mission, without so much worrying about the well being of the humans, who are just the means to that goal.

To take a quick detour and discuss a bit of the reasons, now that it's mentioned. the reasons of "why we would embark on a interstellar mission?". And the ones used most, in sci-fi books and movies for example; are complete and utter destruction here on Earth, or the certain unhabitability of Earth. Whch could occurr, maybe not now, but perhaps many millennia into the future. Where some theorize the Earth may become "inhospitable enough" for us to want to go look for "friendlier more welcoming places". Again, this would be very far into the future, if it even happens at all. Again, one issue with these reasons, of utter collapse, is that, as of right now; we know of no place like earth. Anywhere in the universe, as per the small amount of research we've done on the subject. A place that is as hospitable as Earth, for us of course. But, this may change in the future, maybe in the near future. our knowledge of other "exoplanets", as they call them, may continue to expand rapidly. As there are telescopes which are operational, at this moment, such as the James Webb telescope, which is perhaps going to shed more light on that field. And, perhaps, we may learn of more exoplanets, some may be much like Earth, or even more hospitable to human life, potentially. But, as of yet, there is no such place that we know of. others argue that it is a lot easier and less resource consuming to "not destroy" the earth, or to stop destroying the earth's environment, and to even rejuvenate the earth, or fix the earth. Rather than embark in finding another earth. So, in other words: make the earth last a lot longer, and make it, or keep it a lot more habitable; as much as we humanly can. and possibly make it better as much as our knowledge and technology will allow us.

another popular reason is worldwide catastrophe whether it's the strike from an unsuspecting meteor, or chickaloop scale meteoric event. One that may threaten our existence here on Earth. Again, this is probably even less likely to occur; than environmental collapse, largely because of the likelihood of any impact from space is so low, at this moment in our solar system. And, also our current technological abilities, would probably allow us to deflect, or nudge, such celestial body that is

incoming; just enough so it can “miss us” perhaps by a few thousand kilometers. so again, I would think these surprise meteors unlikely to happen, with our current technology; we are good and getting better at tracking celestial orbiting bodies that may come close to Earth. and even more so if they are large enough to cause mass extinction. so that is likely not to be a big problem for us in the near future, or in the far future especially.

Another popular idea, of why we would want to leave Earth or at least a good portion of us, a sample of the human population; is to ensure our continued existence in the universe. On overpopulation; there are fears, by some people or perhaps many people, that the earth will run out of space for humanity. That is will cease to be sustainable and we may quickly run out of resources due to “runaway” population numbers. But, this is unlikely. As most industrialized or “advanced” nations’ populations generally come to a plateau, or eventually get there. This is where people, on their own accord or other factors have less children, and populations seem to plateau and even decrease over time. And, this is a pattern that happens over and over, with industrialization and advancement, with technology advancement and those in education, quality of life, etc. so this is quite unlikely, right now, humans populate all over the place, all over the globe. they inhabit many different areas of the world but not really a significant percentage of the available land mass of the world. when you look at the available square mileage or square kilometer land area available on the earth, especially those that are habitable; it is almost insignificant the amount of land that we are currently inhabiting. so we have plenty of space for use, and the among the limiting factors that we face, on populating those areas is our choices to limit ourselves. limit immigration, limit where we can and cannot go and live. Mostly for political, cultural and racial pretexts. So it is not, for the most part, something that is a physical limitation, or a limitation of space. Again, we have plenty of space as we don't occupy perhaps even 10% of the earth's land mass. even if we allow for generous areas for each human. and this is likely not

to change for many more millenia, and as we advance into the future. So, I believe that overpopulation is not a good reason for us to embark on interstellar travel. and personally, anything outside of the “want of exploration” and the “voluntary expansion of humanity” and life into the universe; are just not real good reasons, not justifiable, and unnecessary. I think, personally, it would be an unnecessary endeavor to leave Earth because we can't take care of it; or because we give up on taking care of its environment; or because we think that we're not going to have enough “space”, when simultaneously there's people with thousands of acres of land all around them, who “claim” they “own it”, and they put picket fences and no trespassing signs all around their huge ranches, and boldly say that “the earth is overpopulated”. So, I believe, these are not good reasons to look for other earths with plans to leave our own.

The best reason, I believe, on which humanity may decide to embark in interstellar travel; would be just the voluntary expansion of life into the universe. not by necessity but by choice. because we want to and because we see it as something that is beneficial. Beneficial for not only the people that may remain on Earth, but to life itself, and for whatever purpose we believe life has. we may also believe it beneficial to expand our reach, our capability, and spread life’s existence in the universe. And for the remote, but yet a possibility, of contacting other life.

So to move on to “closed and hostile environments in space”. That has a lot to do with human factors, especially for a interstellar mission. A mission to another star system, other than our own, which will be by definition very long and isolated. and the time and distance are going to compound challengens, and make whatever environment we inhabit, enclosed for long periods. whatever environment the astronauts occupy, whether it be a huge ark or a smaller more conventional spacecraft, those will necessarily become closed and perhaps hostile environments. they will be necessarily closed environments because the spacecraft itself, with current technology and with our current capacity for

building them; will be necessarily smaller and limited in size. Therefore, relatively cramped, therefore limited in habitable space and perhaps quite spartan. Also, there will be little space for storage of food, water, and other supplies. Commodities such as food growing will likely be limited. So, the crew and the equipment will likely be small, again if we are to use current technology.

So, the crew will likely have limitations of movement. you won't be able to go out and run a mile or two around the ship, most likely, because of the space limitations. you may have to run that mile or two on a treadmill. And you may not be able to play tennis or football on a full size field on the ship. because of the, again, space limitations. so you will be limited as far as movement, and that makes it a enclosed environment. you will also face, more likely than not, a hostile environment when it comes to the microbial population. NASA pretty classifies the hostility of an environment due to its danger when it comes to biology or microbes, bacteria, disease, etc. those will likely become problems in an enclosed environment in space, very quickly, especially if there is low or zero gravity throughout the trip. throughout the duration of the mission, bacteria may evolve and change into harmful forms. even bacteria that are neutral or friendly, within our bodies, may evolve into something that may be harmful. and again, this could happen a lot more rapidly during low gravity.

the hostility in these environments may also come from other people, fellow astronauts. people may have disagreements, and that's almost a certainty that there will be disagreements among people. there will be, perhaps, pretty deeply held beliefs and customs, deeply held ideologies that can clash or that are incompatible with other people’s. and these clashes may uproot or unearth other problems, such as indifference, hostility, even such as even violence. cooperation may quickly breakdown, and limits may set in communication. These and more conflicts may occur due to these cultural and other tyopes of differences, and the inability to put those differences aside, or not allow those differences to affect the way you behave with other people; may be difficult to achieve. your friendliness, politeness, your

cooperation level, again; may suffer and affect the mission. And the communication level of those around you may be impacted as well, and the mission may be impacted, perhaps negatively so. and perhaps, even bigger problems may arise; at worse compromising the mission, or causing mission failure. Also, there may be escalations of hostility and even violence, that may lead to problems as serious as crew attempts at hurting each other, or someone hurting themselves. and even there may be attempts at murder and perhaps one or more of those attempts may be successful. it is not inconceivable that these things may happen in space, and that makes whatever environment this is occurring at; a hostile one.

it is not necessarily the case that the that the crew will make the environment a hostile one but it may very well become one just due to the environmental factors and the human nature. And the mission must be ready for this likely possibility, and must be able to either prevent it or deal with it effectively if it does arise. and perhaps fix and sort out the problems, and come to remediations of whatever environmental problems may arise. Again, because these cause other issues, such as non-cooperation. Again, this convoluting many other problems.

A major factor that makes human conflict likely, in space, is the duration in which this human population will be together in an enclosed environment, i.e. the spacecraft. So, the longer the trip goes, again with current technology we're foreseeing about several thousand years en route; problems will surely arise. and many may arise to the level of severe consequences. However, there are methods to mitigate these problems, but we have very little experience with these methods, and with long duration crewed flights. and we have precisely zero experience with ultra long duration flights, such as many decades, to hundreds, to thousands of years of human space habitation. As such, we have no idea what may come from such long duration in space.

The next challenge of interstellar human space flight is isolation. isolation present challenges dealing with human factors similar to those of “distance from Earth” and “hostile environments”. isolation will change the mood of the crew, most likely, especially in its initial phases of the mission. isolation is basically the feeling of separation, the perception of being alone and too from familiarity and safety. And, no other place is more familiar and comforting to us than Earth. as discussed, an interstellar mission will likely be a one-way trip, where a crew will be “cast away” from Earth. And feelings of isolation may begin to settle as soon as you blast off from the Earth's surface. And, because of the vast distances of space that will have to be traversed, and the hundreds to thousands of years of duration of the missions; this will necessarily isolate the crew. Additionally, the time that will pass between the mission start and arrival at whatever star system that the mission goes to; will exasurbate the feeling of isolation. Even, if it's the nearest star system, at current technology levels; it will be at least hundreds of years en route. This is absolutely umpresedented. And again, compare this as if trying to communicate via telephone, with an Egyptian or Sumerian, in their timeframe. if this was somehow possible. To communicate between the vast time difference, hundreds to thousands of years. The difficulty is obvious, or even impossible, because of the environmental and cultural references necessary for communication, simply would not exist. The reference differences would be so vast that we'd be talking to someone from another planet, as would be ignorant of all the technological advances and knowledge that we have gained. Communication along large distances may occur, to some degree, but just imagine those issues of gap and unfamiliarity; multiply by orders of magnitude for interstellar flight. So isolation is also the separation of ideas, language, technology, culture, and more. And earthlings and crews would eventually become two different cultures, then races, and ultimately different species. An offshoot species from humanity, that broke off from Earth and became biologically different.

Additionally, Isolation affects the way we think and behave, and the course of development of our technology. I would believe, it can be especially different, the course and change in technology. That which would take place on Earth, and on the ship. whether it's the case that earth technology advances a lot faster, or the ship's. as far as technology goes, or the technology on the ship, advances will depend on the need and resources available. Presumably, resources are a lot more abundant on earth, but the need is much greater in a starbound ship. So it is hard to estimate who's technology will lag or lead. And the vast difference in environment would likely create different types of technologies, or necessitate different types of technologies; where the evolution of technology would be vastly different. Technological paths would likely "cleavage" and stray away far from each other.

So, isolation would be a significant challenge for a human crewed interstellar mission; of course because we would have to worry about the human factor. The sometimes unpredictable effects isolation will have will be likely unerving and difficult to address. Pressing worries; "what will the crew do on board when feelings of isolation settle?"; "what will happen socially?"; "what will happen biologically?"; "what will happen psychologically with these people?"; once they are "broken off" to remai on their own. will the worst of our traits surface and take over the mission? perhaps despotism may arise, and disrupt the command or hierarchy on board. Order could devolve into something like a kingdom or a monarchy, or even a dictatorship. Or, will isolation be managed, after those most affected are addressed; so most of the crew continues without much issues. Or, will issues with participation and cooperation be disrupted. there is "little telling" on the behaviours that develop during isolation, but one thing is almost certain. once the ship "leaves"; it will be up to the crew what they decide to do. Ultimately, it is up to them. although, yes, their oaths, their promises and training will play a very large factor in what they do. But, it is unknown what exactly will happen, especially when we're talking about "multiple generations" which will be born and die en route. There's little predictability as to what

will the next generation be like, or what will they decide to do, or what changes will they impose, vote upon or enact in the future. there is little telling. So, isolation makes for much unpredictability about the human factor. But the little we know about isolation, makes it a bleak challenge to deal with.

While talking about the “unknown”; I would like to bring up the last set of challenges that I would like to discuss. And it is the very fact that there are a lot of “unknowns” in space. once the interstellar crew goes on this very long and challenging mission; to whatever star system. even if it's the closest 4.4 light years away; there will be many “unknown factors”. Some of these factors may be “discovered”, and perhaps some of them will not even be “registered” by the crew. These are the most challenging as you may not know “what just hit you”. many unknowns perhaps will be “learned” or even solved, en route. When I say solved, I mean, understood. There’s a difference. I believe that the human mind works in a way that “thinking about the problem” can help help solve them. Meaning, understand the problem enough to prevent it’s ill effects. Of course, some problems have baffled many on earth, or most people. But even for these; there may be discoveries made en route. for example, dark matter and dark energy which are utter unknowns right now. But, we believe “must exist” because of other observed phenomena.

Some unknown fators may be understood, even manipulated and harnessed, by those star bound folk. Or, the long sought after answers to problems on Earth and on board, such as the prevention of some diseases such as cancer, AIDS, alzimer’s, dementia, and others. Some or all of these, maybe, would be solved in space; through laser focused research and efforts. So for example, through gene manipulation we may be able to “stumble” into the prevention of cancer. Or, AI may, all of the sudden, suggest an effective vaccine to prevent illnesses such as AIDS, Herpes, etc. Or, we may fix the effects of illnesses with organs heart disease, diabetes, Alzheimer's; through advanced surgery. Or we may be able to reverse the effects of diseases through cell replacement. These possibilities, while speculative, I

believe are possible. As you've probably heard, there are claims that future folk will discover a way to slow aging to a point where we could extend our lives and quality of life significantly. But, i'm not going to speculate how much and how long. Just say that it could be "by a significant margin". But, i don't believe, like many do, about being able to extend life "forever". i don't know if most people would even want that prospect. But I don't think it possible since not even the most complex and large, or simplest and smallest structures in the universe remain as they are forever. Change is, I believe, a universal necessity. And living forever is incompatible with change. change must occur. So, let's imagine for a minute that we can "live forever". in what state do we "live forever"?; do we "freeze" a certain state in our lives? And what "stage" of your life should that be? is it in your mid-40s is it in your mid-20s; it as a child is it as a older adult? there are too problematic many questions there, and too many ill consequences to even consider that. It could be something that may be possible in the future, to some extent. But, again the "extension of life" may be something that is discovered either on Earth, before any interstellar trip or travel effort, or while the mission is already en route. Again, this may be done by people or advances machines. But, these would be possible only with the advance of space medicine.

Space medicine may advace to the point where health may not be a worry, or may not be a "worrying factor". Health may become something that it is "taken care of", perhaps by automated systems. Also, there is a possibility of cybernetics advancing to the point that they "blur the line" between the living and the synthetic, or between biological and machine. as many of our sci-fi films and stories, from as far as memory goes, say or account. there may be a time where what we often call cyborgs, half human and half robots, hybrids whatever the name of the time may be; become commonplace. Perhaps speeding up our current trend, where we are, right now, using smart prosthetics, implants with brain connections, and synthetic organs such as to robotic limbs. for example, robotic

arms and hands, that could be controlled by brain impulses, somehow picked up by these machine's wiring. These smart implants; we are doing that today, so that may evolve and rapidly advance in the future, perhaps to a level so inconceivable; we may begin to implant artificial vital organs, such as lungs, livers, kidneys, hearts. Even perhaps eyes and other very critical organs may be replaced with machines that realy perform at the same or better level as the original. Even some areas of the brain may be replaced by computers, or computer-like equipment, or even entire brains may be replaced by a computer. And althogh many of these future possibilities are speculative, there may be a time that our technology may surpass our current imagination. This has happened before. for example, in computing artificial intelligence, robotics, electronics, etc. For example, the past centuries' people coult not fathem the commonplace of television and telecommunication using "devices". Such takk would be likely considered sorcery and witchcraft.

Other type of technology, that we yet are to develop, perhaps a combination of computing, AI and robotics. Or perhaps, something entirely new, something that's more in the solid state area of science. Or maybe, technology in the organic state; where we may come up with yet other types of technologies. The possibilities are many. For example, organic based spacecraft. Like ones in a video game I remember from years ago. There, spaceships are basically living organisms, that are grown and modified or upgraded. Those were able to live in space and be used as arcs, for different races, so this may that could become possible to some degree, perhaps in the very far future.

It is hard to know, of course, with any kind of certainty; but it is these "unknowns" that make an interstellar mission also very attractive, captivating and something that we may want to "go for". For the advancement of our knowledge, not only of technology but the advancement of civilization and humanity as a whole.

Finally, I’d lke to speak on what I believe will take place for humans in the far future. Specifically dealing with interstellar travel. These are my opinions and my estimations. my humble and illinformed; layman's view or estimation of what may happen in the far future, for humanity, for our species in the cosmos. I believe that, in the far future, we *will* fly among the stars. And, that we *will* go to other star systems, perhaps beginning, of course, with the most obvious, our closest star system; the Alpha Centuri system. But, perhaps this will not happen in the way that most of us think it will” humans valiantly and finally coming together in cooperation, and building vast mega starships, using orbital structures. and embarking, in concert, in caravans of huge ships; into a heroic interstellar mission. Perhaps to Alpah Centauri. With astronauts, people, and our very best minds hard at work. I believe this *is* “what” a lot of people think about; when they think of “interstellar travel”. Perhaps with some variations, like with one ship instead of many, or arriving at the destination in “years’ time” and not centuries. Or, somehow accelerating to a good percentage of the speed of light, perhaps over 50%, then arriving at the alpha centauri star system, again in perhaps in a decade or so. These ideas are all fine. To wish and to think this way. But, with a little investigation, as I’ve done here. They are exposed as utterly unrealistic. I believe that when we do finally head to the stars it won't be us at the helm. it won't likely be humanity even building the ships, or even planning the mission. it won't likely be humanity even piloting and controlling the systems that take us there. No, instead i believe that, in the far future; we may be laidback and lazy, perhaps incapable of performing the tremendously difficult tasks we once did. Incapable of taking the charge that we once did. And, probably, in our comfort; depending on computerized, automated, artificial intelligence systems, to do just about everything for us. We would depend on these systems to do our planning and all of the work for just about any task. whether it's calculations, design layouts, developing methods, developing systems, or even manual labor. so it would be, I believe, computing and artificial intelligence that will develop to the point where humans will have to do very little. especially so on “high-end tasks”, sucha s the ones required

to traveling to the stars. I believe that space missions, especially interstellar missions; would require extremely advanced computations, thinking and extremely heavy labor, to include the gargantuan efforts to plan-for, design and build the ships in-orbit, and bring about the cooperation and logistics needed for such undertaking. The detailed and meticulous planning and execution of that project will likely surpass human capability. Just like space travel would not be possible without telecomunication and rockets. Interstellar travel will likely not be possible with advanced systems in control. I believe we *will* come to the conclusion that" all of that is better done by their ultra smart systems. And that we, once upon a time, in the far past; lost our way. And, luckily developed developed artificial intelligence to take us beyond earth. I believe there may be a point, perhaps in the near future, where artificial intelligence will match the capability of humans in every conceivable way. in thinking, planning, executing tasks, computing, designing, in coordination with other machines and other systems. and all of the mechanical tasks would be better done by machines, just as they are done much better and faster, and more efficiently by machines in automated manufacturing plants today. So, if the current trend continues, and I believe very strongly that it will, in those many areas that are very significant and very relevant to space exploration. Machines will necessarily take charge, or be more critical to our survival than us. Again, technology dealing with advanced and alternative methods of propulsion; the study of quantum based science, and interstellar space, etc. Because we are yet limited in our knowledge of the cosmos, for example, we don't yet know if the universe in infinite or how large, as we are limited to the "known universe" by our instruments and current knowledge of physics. But, if our research is somehow "automated" and it exponentially speeds up. This may occurr to the point where machines, or computers or robots, whatever you want to call them; are going to have "taken over". Take over, not necessarily us, enslave us; but take over those tasks and "run with them". And they, perhaps, along with some input from some humans that remain in positions of authority; may "decide" *to go*. And, finaly take humanity and other biological life; along to the stars!

By that time when “they”, the machines, may think of themselves as alive, as conscious. Specially since “consciousness” is a hard thing to define, and that “definition” may be further “blurred” in the future, with the “coming” of extremely smart systems. These feelings of “belonging” and the possible “personification” of non-biology. May arise as a result of advacement. Machines, as many sci-fi media have presented; may become so “smart” that would duplicate the feelings, the thoughts, the culture of humans. They may match these so closely to ours and with such fidelity that humans themselves may not be able to tell the difference between machines and themselves. Maybe, humanoid and other machine based-beings would demand human rights.

I believe these to be more likely to occur, in the very far future, with interstellar travel. I often believe otherwise; attempting to project a lot of what we know from our present, into the future. But I believe this often a mistaken approach. Although it may “work” sometimes, it may turn up to be right. But, I believe many times more, it is the wrong approach to think in current terms. For example, I’ve been reading a Manga (Japanese comic) called Akira. And, the setting is the future, 2077. And, the manga having been created in the late 1980s, they included a scence where they still use photography film. In other words, the creators could not envision that film would be replaced by digital photography. So, to think of future possibilities, you may stay based in current technology, but you have to “mix things” or change things a lot. Or, make current things “extreme”. Because I believe that's the trend, in which someone from the past would see today's world as utterly extreme in most ways. So, you would need to think extreme; when you think about the far future, because what seems to be the trend. Even today, in many instances, extreme seems to be the norm.

I believe, also, is the “give and take” we must consider to think about the future. If you develop a lot in one area, you take away from another. I believe that is a natural phenomena, in our universe, for all to balance. For example if you spend a lot of effort and time; doing one type of work, you are

utterly forgetting and I would say ignoring another area. An area in which you are going to be underdeveloped, or lacking knowledge, lacking skill and practice in it. I believe this will occur at one point, where humans will become so dependent on technology that we will become inept in many ways. because again, that is the trend today. We depend on computers, what we call smart devices; phones, laptops, tablets, etc. We depend on these a lot more than we did “say” 10 years ago. and certainly do a lot more than 20 years ago. so the “trend” is what that tells me that we will likely continue to depend more and more on technology. more and more on smart systems, to do things for us. such as being guided by our GPS applications, instead of looking at road signs, landmarks, or figuring out where we are otherwise. Almost no one on the road uses a compass, for example, to see what direction they're headed; all they have to do is look at their phone screen it has a compass on it. And, surely, no one relies on paper maps. Of course with few exceptions.

So, in summary, these are the things I believe will happen. We, as people, will be “taken for a ride” to the stars. Riding along with, I would say, semi-scentient, semiconscious and extremely capable artificial intelligent systems. Systems that will design, build and launch; unimaginably capable spaceships. Spacecraft that have ultra efficient with powerful propulsion systems. Machines will likely perform breakthroughs with propulsion and many other space travel systems, and perhaps solve all of NASA’s five hazards of human space flight, or all the problems that I discussed throughout this paper. Breaktrhough in propulsion, gravity systems, anti-radiation, space medicine, and more. They may perform breakthroughs in all of those systems, all of those areas; very rapidly and with unpresedented efficacy. And, before we feel ready, they may “take us to the stars!” Finally, I believe these to be more likely than us doing “it” on our own, at the helm, and in control. Where we finally leave our egos in the dust, and accept our diminished status in the grand scheme of the cosmos.

Thank you very much for reading.